GOVERNMENT OF INDIA
MINISTRY OF COMMERCE & INDUSTRY,
PATENT OFFICE, DELHI BRANCH,
W-5, WEST PATEL NAGAR,
NEW DELHI-110 008.

I the undersigned being an officer duly authorized in accordance with the provision of the Patent Act, 1970 hereby certify that annexed hereto is the true copy of the Application and Complete Specification filed in connection with Application for Patent No. ***753/Del/01*** *dated* ***9th July 2001****.*

Witness my hand this 18th day of December 2001.

(H.C. BAKSHI)
Deputy Controller of Patents & Designs.

FORM 1

THE PATENTS ACT, 1970

APPLICATION FOR GRANT OF PATENT
(See Sections 5(2), 7, 54 and 135 and Rule 33A)

(1) We, 1- MR. SAMIR GUPTA C/O. PINKCITY GEM TECHNOLOGIES, 76 DHULESHWAR GARDENS, JAIPUR
2-MR. MANUJ GOYAL C/O PINKCITY GEM TECHNOLOGIES, 76. DHULESHWAR GARDENS, JAIPUR

(2) hereby declare –

(a) That we are in possession of an invention titled

(a) that the Complete Specification relating to this invention is filed with this application;

(b) that there is no lawful ground of objection to the grant of a patent to us.

(3) further declare that the inventors for the said invention are:

1. MR. SAMIR GUPTA
PINKCITY GEM TECHNOLOGIES
76, DHULESHWAR GARDENS
JAIPUR - 302001

2. MR. MANUJ GOYAL
PINKCITY GEM TECHNOLOGIES
76. DHULESHWAR GARDENS.

(4) We claim priority from the application filed in the following convention country, particulars of which are as follows:

NIL

(5) That we are the true and first inventors.

(6) That our address for service in India is as follows:

SUBRAMANIAM, NATARAJ & ASSOCIATES
Attorneys-at-Law
E 556, Greater Kailash II,
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(7) That to the best of my/our knowledge, information and belief the facts and matters stated herein are correct and there is no lawful ground of objection to the grant of patent to me/us on this application.

(8) Following are the attachments with this application:
- (a) Complete specification in triplicate
- (b) Application forms 1 in triplicate
- (c) Statement and Undertaking on FORM 3 in duplicate
- (d) Abstract

Fee Rs. 1500/-...... in Cash/Cheque/Bank Draft Bearing No. 583764 dated 17/5/2001 on Citibank Bank.

We request that a patent be granted to us for the said invention.

Dated this 9th day of July 2001.

(SAMIR GUPTA) (MANUJ GOYAL)

Signature

The Controller of Patents
The Patent Office,
At New Delhi

FORM-2

THE PATENTS ACT, 1970

COMPLETE SPECIFICATION

(SEE SECTION 10)

ORIGINAL

A PROCESS FOR IMPARTING AND ENHANCEMENT OF COLOURS IN GEMSTONE MINERALS AND MINERALS OBTAINED THEREBY

-9 JUL 2001

753 DEL 1

Samir Gupta and Manuj Goyal, both Indian citizens, of PINKCITY GEM TECHNOLOGIES 76-Dhuleshwar Garden, JAIPUR – 302 001, Rajasthan, INDIA

The following specification particularly describes the nature of this invention and the manner in which it is to be performed:

A PROCESS FOR IMPARTING AND ENHANCEMENT OF COLOURS IN GEMSTONE MINERALS AND GEMSTONE MINERALS OBTAINED THEREBY

Field of the invention

The present invention relates to a process for imparting and enhancement of colours in gemstone minerals and to gemstone minerals obtained thereby. In particular the present invention relates to a process for imparting colours to colourless gemstones and enhancement of colour of paler gemstones and to coloured gemstones manufactured thereby. Even more particularly, the present invention relates to an environmentally friendly process for inducing colours and for enhancing the properties of gemstone minerals and to novel coloured gemstones obtained thereby.

Background of the invention

In the field of personal adornment, coloured stones have assumed great significance to the extent that demand today far surpasses supply. In view of the expense and costs involved in obtaining coloured gemstones, a search is on for alternatives to coloured stones. A vast range of coloured as well as colourless minerals used as gemstones are being mined all over the world. The stones so obtained are cut and polished to make them suitable for a specific use. Such precious and semi-precious gemstones are extensively used in jewellery, decorative articles and ornaments. As demand of coloured stones is huge compared to their natural availability, colourless and low coloured natural gemstones are subjected to variety of treatments to enhance their properties like colour, lustre or transparency.

Certain colored stones and crystals have been sought and prized for their beauty beginning with ancient civilizations and continuing into the modern age, even to the extent of ascribing to them magical powers. Through appropriate cutting and polishing, the value and natural beauty of a precious stone may be further enhanced. While a vivid color is not always a requirement for a jewel, i.e., cut stone, it is an important attribute of red ruby, blue sapphire or green emerald. Furthermore, the color or lack thereof may be an important attribute of relatively clear gems, such as diamonds.

Besides its visual beauty, a gemstone for ornamental purposes has to possess a certain amount of durability to be classified as precious, since it should be displayable by the owner without fear of deterioration or tarnish. Gemstones of the requisite hardness to qualify as durable include gem varieties derived from corundum (e.g., ruby, and sapphire) and from carbon (e.g., diamond). Such gemstones typically not only outlive their wearers but also sparkle with undiminished luster long after their metal setting has been abraded or eroded.

Finally, naturally occurring gemstones generally are of higher inherent value than artificially grown gems, regardless of the fact that artificial stones often are of purer color and higher internal crystal quality. Although this result is probably attributable to the lack of rarity in the artificial stone, some minor flaws in naturally occurring stones are thought to add beauty and character to the final jewel.

Naturally occurring gemstones may exhibit undesirable color zones in which the color is distributed unevenly in the gem. The uneven color zones generally make it more difficult for the lapidary to select the direction in which the gem should be advantageously cut. On the other hand, colorless crystals often are less attractive than colored ones.

Various attempts have been made to produce jewellery items of inexpensive materials with the appearance of expensive materials. For example, U.S. Pat. No. 1,005,564 describes a technique of employing coloured sheets of celluloid to form various shapes to represent various natural materials and gems, such as coral, turquoise and the like. U.S. Pat. No. 4,295,347 describes other techniques employing lacquers on a substrate in order to simulate the appearance of a gem. U.S. Pat. No. 4,835,023 describes the use of various coatings on cultured pearls in order to improve the quality of the pearls. However, till date, the techniques employed to process an inexpensive material to give the appearance of an expensive material have been cumbersome, and, in some cases, have not achieved the desired result.

US 6,146,723 discloses an enhanced gemstone and a method of simulating the appearance of an expensive gemstone. In the process of this invention, a clear crystalline faceted substrate is provided with a coating of coloured transparent ink in order to enhance the appearance of the otherwise inexpensive gemstone. The ink is permanent type ink made from n-propanol, n-butanol and diacetone alcohol, which is soluble in a solution having isopropyl alcohol 99% strength. Once the coating has been applied to a substrate such as a cubic zirconia to enhance the appearance of the gemstone, the coating is removed by use of the solvent.

United States Patent 5,853,826 discloses a method for the improvement in the colour of transparent materials including gemstones. A faceted gemstone having at least one thin layer of material is coated on the pavilion of a transparent substrate so that the body of the gemstone appears to have a different color. The color of reflected light changes hues when viewed through the face of the gemstone at different angles of observation. This causes the gemstone to appear to change color when the stone is tilted. The thin film is coated by low temperature techniques such as sputtering.

A number of processes have been developed to improve the appearance of gemstones or to create simulated gemstones. Diffusion of ions into gemstones, such as titanium and/or iron into sapphire to give a blue color has been disclosed. This process is limited to specific ions and specific substrates. This process requires extremely high temperatures, which frequently damages the substrates. Diffusion processes cause the added ions to become part of the crystal surface with no distinct boundary and usually form a gradient of ion concentration in the base substrate. Examples of diffusion processes include U.S. Pat. Nos. 2,690,630 and 4,039,726.

Tavelite™ is a product produced by depositing thin multiple layers on a transparent substrate to produce an interference effect. The process utilizes high temperatures and frequently results in substantial breakage of the product.

Aqua-aura™, a product of Vision Industries is a surface treatment providing a single, moderately saturated, color. This process is proprietary but is reported to be a coating based upon gold and the use of high temperatures.

Nuclear radiation has been used to produce color centers in gemstones, giving a body color that can sometimes be improved with heat treatment. Cyclotrons and neutron bombardment are routinely used to impart blue color to colorless topaz.

Rhinestones and Carnival Glass have reflective coatings layered on one or more surfaces of a clear substrate. The coating is usually silver or some other highly reflective material utilized to apply a mirror coating (usually silver or aluminum) onto the pavilion (back) of a faceted glass gem. In such a coating, all light is reflected without passing through the coating. Atmospheric pressure chemical vapor deposition has been used to deposit films of titanium oxide by the thermal decomposition of a titanium compound (usually $TiCl_4$) in air.

Layered coatings on a surface of gemstones have been done to increase the "fire" of the stone. These techniques involve the coating of a highly refractive material, with respect to the gemstone's index of refraction, followed by a second coating of a different highly refractive material. The layers are designed so that the reflected light at each interface of each layer causes an optical interference effect. An example of such a method is U.S. Pat. No. 3,490,250.

U.S. Pat. No. 5,084,909 describes color enhancement brought about in natural and synthetic gem materials by high-energy gamma ray fields for extended periods of time (50 to 1000 hours). High-energy radiation fields are necessary for this process. It is extremely interesting to note that disclosed in this reference the inventor utilized heat to bleach or

remove unwanted colors from the gems (either before or after a well-known color enhancement procedure that involved electron bombardment). Therefore, this reference clearly teaches that heat has been utilized not to enhance color but to lessen color intensity in at least gem-type materials.

U.S. Pat. No. 5,477,055 presents a thorough review of the history of coloring precious or semi-precious gemstones via single or combined radiation treatments. The color enhancement process related is a two step method that includes fast neutron irradiation at between 350°C to 600°C followed by gamma ray or electron bombardment. Higher temperatures tend to fragment the gemstones. The elevated temperatures (above room temperature) tend to reduce unwanted side (blue-gray) colors.

U.S. Pat. No. 4,749,869 discloses a process for irradiating topaz and the product resulting therefrom. A three-step method of color enhancement is described in which a sample stone is: 1) exposed to high energy neutrons; 2) exposed to electrons; and 3) heated to between 250°F (121°C) and 900°F (482°C). The heating step tends to "bleach-out" or remove unwanted side colors, thereby enhancing the desired blue color.

U.S. Pat. No. 2,945,793 discloses a method for heat treatment of diamonds to increase desirable colouration. Irradiation by electrons in followed by heating to about 500°C to again, decrease undesirable tints within the diamond. However, this invention relates specifically only to reducing the color of diamonds in order to enhance the clarity and transparency.

United States Patent 6,025,060 discloses a method and apparatus for creating unique gemstones. The method comprises the steps of optically contacting the gemstones of interest followed by a heat treatment of the composite gemstone. The heat treatment step increases the bond strength and therefore the resistance of the bond to reversal. In one aspect of the invention, a composite gem is fabricated by bonding a naturally occurring gem to an artificial gem to form a single composite gemstone of large size that outwardly appears to be a single natural gem. The composite gem may be fabricated at a fraction of the cost of a natural stone of the same size. In another aspect of the invention, an intensely colored natural stone is bonded to a colorless or lightly colored artificial stone. This composite retains the intense color associated with the natural stone while enjoying the brilliance, depth, and size resulting from the combination of stones. In another aspect of the invention, various composite gemstones are fabricated using a variety of stones of both natural and artificial origin. The stones may be layered with two, three, or more layers. The composite gem may either take the form of a simple layered gem, or the composite gem may be in the form of a variety of three-dimensional shapes. In another aspect of the invention, the composite gem includes an

engraved pattern at one or more internal gem interfaces. The engraving is completed prior to bonding the stones together and may convey either a two-dimensional or a three-dimensional image.

U.S. Pat. No. 4,039,726 discloses changing the colour of corundum by diffusing chromophores such as iron/titanium, chromium, chromium/nickel, or chromium/iron/titanium into natural or artificial crystals at temperatures typically above 1700°C.

In the last decade, a variety of techniques such as electron beam irradiation [U. S. Pat. No.5637878, Herer, Arnold S., Knobel, Thomas M. and Robb, Gregory J., June 10, 1997}, Cobalt-60 irradiation [U. S. Pat. No.5084909, Pollak, Jan.1992] neutron bombardment [U. S. Pat. No.4749869, Richard Fournier, June 1988], heat treatment, diffusion and the like, have been employed in the art to produce colours in colourless gems and/or enhance the properties of coloured stones.

However, the hitherto known processes mentioned above suffer from significant drawbacks in term of cost, safety, efficacy and the like. In irradiation, a widely used commercial process, the stones are exposed to a beam of high-energy subatomic particles or electromagnetic radiation such as neutron or gamma rays either to enhance colour or to produce a colour in colourless stones. Commercially used radiation includes: high-speed negatively charged electrons from a linear accelerator; high-speed alpha particles (positively charged helium nuclei) from either a linear accelerator or a cyclotron; energetic neutrons from an atomic pile; and high energy gamma rays from a Cobalt-60 source. Charged particles induce colour skin depth due to their small size while high-energy neutron and gamma irradiation colour the whole stone. The dose and energy of the particle beam determine the quality and degree of colour induction in gemstones. Subsequently, the irradiated samples are heat treated to stabilise the colour. For example, diamond, zircon, topaz, quartz, corundum, beryl etc. are subjected to irradiation for enhancing their colour and appearance. [R. Webster, 'GEMS' Butterworths - Heinemann Ltd Oxford, London, 1994]. Heat treatment is an ancient method to enhance properties of most of the gemstones. Quartz, topaz, zircon, corundum, ruby, sapphire, amethyst, citrine, aquamarine are examples of gemstones whose colours can be altered by heat treatment (Ted Themelis, "The heat treatment of Ruby and Sapphire' ISBN 0-9409-6510- 0, Published by Gemlab. Inc., Type-ergraphics Inc. USA] In recent years, diffusion technique has also been reported to produce colour in gemstones. [J. I. Koivula, and R. C. Kammerling, Gems & Gemmology, Vol.26, No. 1, PPI00-101]. In this method, the gemstones are heated in powder of a metal or a metallic compound at a high temperature to produce colours in them.

While irradiation has been established world over as a commercial technique to enhance and produce colour gemstones, particularly for the manufacture of blue Topaz, this technique requires expensive and complex equipment i.e. accelerator to produce an energetic beam of particles. The cost and maintenance of an accelerator is very high. An established safety procedure has to be followed to operate the system and highly skilled operators are needed to run and maintain the equipment. Further, safety demands cooling of the radiated samples as treated stones emit hazardous radiation. Therefore, the irradiated gemstones require storage in a specially designed container for a period of a few weeks to a few months to kill the emission of hazardous radiation from the stones, before these are marketed. Even after this cooling, the samples may emit the reminiscent radiation [Crowningshield, Robert, 'Irradiated topaz and radioactivity', Gems and Gemology, 17, No.4, 1984,pp 179-180].

Another disadvantage in the process of irradiating stones to enhance or impart colour is that of permanency. The exposure of radiated stones to high temperature during use on occasion results in the loss of colour. Additionally, irradiation technique is a multi-step process. The stones are first subjected to neutron or gamma radiation to induce colour, and then subjected to electron exposure for colour uniformity and then a heat treatment at a temperature between 150 to 1100°C for a few hours to stabilize colour [U. S. Pat. No. 5637878, Herer, Arnold S., Knobel, Thomas M. and Robb, Gregory J., June 10, 1997}, U. S. Pat. No.5084909, Pollak, Jan.1992, U. S. Pat. No.4749869, Richard Foumier, June 1988],

The disadvantage of heat treatment processes known in the art is that colour is induced only in some specific minerals. One group of such minerals is called idiochromatic minerals, which contain one of the transition elements as its constituent. The second group of gemstones is allochromatic gems, which are coloured due to the presence of small quantities of various transition elements as impurities [K. Nassau, 'Physics and Chemistry of colour' Wiley – Interscience Publication, John Wiley & Sons, N. Y, 1983]. The third group owes their hue to a colour centre, which is a defect in a crystal, which is able to trap an electron [K., Nassau, 'The origin of colour in minerals and gems.' Lapidary J. In 3 parts: 29: 920-28, 1060-70, 1250-58, and 1521, 1975]. Therefore, the yield of treatment may not be cost effective unless all stones belong to one of the above categories.

Colouring of minerals by diffusion is achieved through heating the stones with a colour - causing compound in powder form. The elements from the powder diffuse into the surface of the stones to induce colour in the surface. This powder-based diffusion generally damages the surface resulting in low yield.

Recently, a two-step process has been developed to improve the yield [U. S. Pat. No.5888918, Pollak, Richard, March 1999]. In this process, initially the stones in combination with a treating agent in powder form are heated together followed again by a high temperature treatment at a temperature in the range of 900° up to about 1250°C for a time in the range of about 3 up to 200 hours in the absence of the treating agent to produce desired colour. The use of two separate temperature cycles will result in low yield and is therefore not suitable for economical commercial production. Another disadvantage observed in this two-step treatment process is that uniformity in colour is not readily achieved.

Objects of the invention

The main objective of the present invention is to provide an environment friendly process for imparting colours and enhancing properties of minerals useful as gemstones which obviates the drawbacks of the hitherto known processes enumerated above.

Another object is to provide a process to produce coloured minerals wherein no hazardous chemicals are used to produce coloured minerals.

Yet another object is to provide a process in which coloured gemstones do not emit any hazardous radiation after the treatment.

Yet another object is to provide a process by which a range of colours can be produced in gemstones.

Yet another object is to provide a process to produce coloured gemstones which do not deteriorates or tarnish.

Yet another object is to provide a process, which requires only one heat treatment cycle to produce colours in minerals.

Yet another object is to provide a process to produce coloured gemstones, which do not loose their colours even if subjected to high temperatures during setting in jewellery.

Yet another object is to provide a process to produce coloured stones whose colour hold very well up to routine wear, jewellery cleaning and repair procedure.

Yet another object is to provide a process, which does not need a complex system or a critical procedure.

Yet another object is to provide a process, which does not require highly skilled operators.

Yet another object is to provide a process, which produces highly uniform intensity colour in gemstones.

Yet another object is to provide a process, which offers an easy control on intensity of a colour being produce in gemstones.

Yet another object is to provide a process, which does not produce physical damages in the stone surface.

Yet another object is to provide a process capable of mass production.

Yet another object is to provide a process, which is highly reproducible and economical for production.

Summary of the invention

In accordance with the present invention, there are provided processes for imparting colours to colourless gemstone minerals and enhancing properties of gemstone-minerals, said processes comprising:

Coating of a thin/thick film of a particular material or multiple films of different materials on polished gemstones to impart colour in colourless stones and to enhance the colour in paler stones.

A wide variety of minerals can be treated according to the present invention. Examples of suitable minerals (useful as gemstones) contemplated for uses herein include topaz, chrysoberyl, sapphire, quartz, garnet and the like.

A variety of techniques can be employed in the practice of the present invention to coat a film of a desired material on the polished stones. Typically, physical vapour deposition, or chemical vapour deposition, or any other technique known in thin/thick film technology and the like can be used for this purpose.

A wide variety of metals can be employed as a film material to deposit the film on mineral stones in the invention process. Examples of suitable metals include transition metals, as well as other metals, which can induce a colour or modify the colour of the mineral being treated.

A wide variety of metal oxides can also be employed to deposit films on the mineral stones in the invention process, optionally in further combination with a plurality of the metals set forth hereinabove. Examples of suitable metal oxides include transition metal oxides, as well as other metal oxides, which can impart or modify the colour of the mineral being treated.

A variety of chemical compounds/alloys can also be employed as film materials to coat gemstones provided one of the constituents of the compound/alloy used contains at least one element capable of inducing colour in the mineral.

Induced or enhanced colours which can be imparted by the invention process can be varied based on such variable as the particular gemstone being treated, the particular film material employed, the conditions to which the gemstones are subjected and the like. For

example, if cobalt is one of the constituents of the film material then topaz can be coloured to a dark blue to light blue colour, or a light green to dark green colour, or a light blue- green to dark blue-green colour, or a light green-blue to a dark green-blue colour depending on the concentration of cobalt in the composition of the film material or thickness of the film if only cobalt metal is used and the heat treatment conditions employed. Similarly, chrysoberyl can be coloured to have a light green to deep blue-green colour; sapphire can be imparted a light blue to dark blue colour or green (if colourless stones are used for treatment), or yellow-green to blue-green stones can be produced if the untreated stones are yellow, quartz can be modified to have a light pink to a dark pink colour, garnet can be modified to have a green to blue green colour: and the like. Similarly, if the minerals are coated with iron or an iron containing compound/alloy then yellow to reddish yellow or pinkish yellow coloured stones can be produced. Like wise if chromium or a chromium containing compounds/alloys and copper and copper containing compounds/alloys produce green and red/pink colour in the stones. Similarly, if two layers, first of cobalt and second film of chromium are deposited then Turquoise-blue coloured stones are produced.

A wide range of cobalt containing compounds/alloys such as cobalt-nickel or, cobalt-nickel-zircon or cobalt-silicide or cobalt-oxide and the like can be employed as film materials to produce different shades of blue to green or their mixed colours in the stones as described above.

A wide range of iron based compounds/alloys such as iron-nickel, iron-cobalt, iron-titanium, iron-gold and the like can be used as film material to produce different shades of yellow or yellow-pink mixed colours in the stones as described above.

A wide range of copper based compounds/alloys such as copper-nickel, copper-gold, copper-titanium and the like can be used to produce pink to red or their mixed sheds in the stones as described above.

A wide range of multiple films of colour inducing different metals, or metallic-oxides or alloys of colour inducing elements can be employed as film/s materials to produce a variety coloured stones.

A wide range of metallic compounds/alloys containing elements capable of inducing colours in the stone being treated can be employed as film-material to produce different coloured gemstones. A wide range of treating conditions can be employed in the practice of the present invention. Typically, conditions suitable to impart or enhance the colour of a gemstones comprise subjecting the film coated stones to a heat treatment to a temperature in the range of about 900°C up to about 1200°C, for a time range of about 30 minutes up to

about 10 hours. Normally, air is employed as environment during a heat treatment process Typically such heating is carried out at ambient pressure

However, the gemstone can optionally be subjected to an inert or a reducing or an oxidising environment while being heat-treated. For inert environment, nitrogen or argon or helium gases and the like can be used while to provide oxidising ambient oxygen and the like and for reducing ambient forming gas (a mixture of nitrogen/hydrogen) and the like is employed. A particular gas is flown continuously during heat treatment to obtain the desired ambient. The heat treatment of coated stones can also be carried out in vacuum to employ a non-oxidising or a non-reducing environment. The ambient conditions significantly affect the colour saturation, intensity and fire of the treated stones. Therefore, a suitable environment is employed during a heat treatment to colour or to enhance the properties of gemstones.

Generally, longer exposure times and/or higher exposure temperatures lead to a greater intensity of colour being imparted to the minerals being treated, as well as imparting the degree of colour saturation achieved by the process. However, higher temperature may cause cracks in the stones if the untreated stones contain hidden defects in the crystals.

Thus employment of higher temperatures or excessively long exposure may affect the yield of the so produced coloured stones. As readily known by the skill in the art, the particular ranges and exposure times will not only vary as a function of the intensity and/or level of desired colour saturation, in addition, the ability of a given mineral to withstand such a temperature without suffering significant fracturing must also be considered. For example, quartz would not typically subjected to conditions as rigorous as topaz or topaz would not be typically subjected to conditions as rigorous as sapphire.

While gemstones can be used in the invention treating process without any special pre-treatment, it is presently desired that gemstones employed in the practice of the invention be cleaned prior to being processed to impart colour or to enhance colour thereof. This pre-treatment is employed only to remove grease or dust particle or any foreign contaminant from the surface of the gemstones. Suitable cleaning methods are well known to those of skill in the art, and include washing in water, aqueous acid, organic media, and the like.

Gemstones treated according to the present invention can also be used directly without any further treatment.

In accordance with another embodiment of the present invention, there are provided coloured or colour-enhanced gemstones having a colour-imparting element/s either diffuse from the film/s material into the surface thereof or form a transparent coloured film over the surface of the stone. The diffused atoms of the colour imparting element/s penetrate in the

crystal to became a part of its structure while atoms of colour imparting elements which form a transparent film over the stone surface, get chemically bonded to the surface atoms of the crystal structure. Colour imparting film materials contemplated include the materials described hereinabove.

In accordance with yet another embodiment of the present invention, there are provided coloured/colour-enhanced gemstones wherein at least the skin depth of the surface of the said stone has chemically bonded there to colour-imparting elements in the film material.

The colour-imparting film materials contemplated include the materials described hereinabove.

The invention will now be described in a greater detail with reference to the following non- limiting examples.

EXAMPLE 1

Cleaning Process:

Stones treated in accordance with the present invention are cleaned as follows. First, the polished stones are cleaned in boiling distilled water containing a small amount of detergent and then cleaned thoroughly in running distilled water. Subsequently, the stones are soaked in a 1:1 aqueous diluted nitric acid for few minutes and rinsed again in distilled water. Dried stones are then cleaned sequentially in trichlroethylene, acetone, and methanol to degrease them. The clean dry stones are now ready for deposition of a film-material.

EXAMPLE 2

Film Deposition:

Clean dry stones are coated with thin/thick film of an appropriate material. Any one of conventional techniques known in thick/thin film technology like physical vapour deposition, or chemical vapour deposition, and the like can be employed to coat a film of a desired material on the gemstones. For multi-layered process, the deposition of film of first material follows the deposition of second film and so on.

EXAMPLE 3

General Treatment Protocol:

To induce colour in the gemstones, film coated samples are placed in a suitable vessel, which can withstand the heat treatment temperatures contemplated for use. A ceramic crucible, or a plate and the like can be used. The vessel is then placed in a furnace capable of attaining and accurately maintaining temperatures in the range of about 900° up to about 1200°C. The desired gas is flown into the furnace to obtain the desired environment and the

furnace is then heated to the desired temperature and maintained at that temperature for the desired length of time. Once the desired time and temperature requirements, to obtain the desired colour are satisfied, the furnace is cooled down and the vessel containing the gemstones is removed.

EXAMPLE 4

Treatment of Topaz:

Topaz is coated with a film of cobalt or a cobalt containing material to achieve a variety of colours. Heat treatments of these stones in a temperature range of 1000°C to 1100°C in air for a time in the range of 30 minutes to 5 hours induces light blue to dark blue colour in the stones. When these stones are heated in a temperature range of 900°C to 1000°C in air for a time in the range of 30 minutes to 3 hours light green to dark green colour is induced in the stones. To obtain mixed coloured green-blue or blue green topaz, the stones are heated in a temperature range of 950°C to 1050°C for an appropriate exposure time. If the process is carried out in nitrogen or a reducing gas ambient intensity and sheds of blue colour in stones can be varied. Similarly, the use of oxidising environment during heat treatment can alter the intensity and shades of green stones.

The coating of cobalt thin film followed by chromium film on topaz and heating the stones in air at 1080°C for 3 hours turquoise blue colour is induced in the stones.

To produce yellow and yellow mixed with red coloured stones, a film of iron containing material is coated and heat treatment is carried out in air or oxygen in the temperature range of 700 to 900°C for 30 min. to 3 hours. Similarly, coatings of copper containing film produce pink to red coloured stones while chromium film impart green colour to the gemstones after similar heat treatment.

EXAMPLE 5

Treatment of Chrysoberyl:

Chrysoberyl is subjected to the same process as described in example 4. Since the common colour of chrysoberyl is light yellow, the colour obtained after this treatment is yellow-green to blue-green, depending upon the time and temperature of exposure. In colourless chrysoberyl this process produces blue colour.

EXAMPLE 6

Treatment of Sapphire:

Sapphire is subjected to the same process as described in Example 4. Care should be taken in selecting the temperature to which the stones are heated to avoid damage. The colour

production in sapphire is like that in topaz i.e. dark blue to light blue, or dark green to light green or a mixed ones depending on the time and temperature cycle employed for the treatment.

EXAMPLE 7

Treatment of Quartz:

Quartz is subjected to the same process as described in Example 4. Care should be taken in selecting the temperature to which the stones are heated to avoid damage. The colour of the treated stones can vary substantially, typically producing stones, which are light to dark pink.

EXAMPLE 8

Treatment of Garnet:

Garnet is subjected to the same process as described in Example 4. The colour of the treated stones can vary substantially, with the invention process typically producing stones, which are green to blue-green when light yellow grossular garnet is used.

While the invention has been described in detail with reference to certain preferred embodiments thereof, it will be understood that modifications and variations are within the spirit and scope of that which is described and claimed.

The main advantages of the technique of the present invention are

1. The process is eco- friendly as no any hazardous chemical is used in the process.
2. The process is eco-friendly, as treated gemstones do not emit any kind of radiation.
3. The process employs conventional thin/thick film technology based technique to coat film material on the stones. Therefore, the involved equipment is not at all a complex system and can be operated by any trained person.
4. An important advantage of the present invention from commercial point of view is that the coloured gemstones produced by this process can immediately be marketed, as no radiation cooling is required in the present process.
5. Only one heat cycle is involved to induce colour in stones. So the heat generated cracks or fractures in gemstones are minimised in the present process.
6. The process produces highly uniform colour all over the surface of the gemstones.
7. The durability and stability of the treated stones against ultra sonic, steam cleaning, boiling in a detergent, heat and chemicals involved in jewellery repair, electroplating and low temperature shock is extremely good.
8. Different shades of same colour or mixture of colours can easily be produced just by manipulating the heating conditions.

9. The technique is applicable to almost all stones for colouring provided an appropriate combination of material and heating cycle is chosen. In principle, the process can produce all possible colours in most of the available gemstone minerals provided an appropriate colour inducing film-material is used to coat the minerals and appropriate conditions are employed for heat treatment.

We Claim:

1. A process for imparting colour to a mineral, said process comprising coating said mineral substrate with a colour imparting material such as herein described and subjecting said coated mineral substrate to heat treatment at a temperature in the range of about 900°C up to about 1250°C for a time in the range of about 30 minutes to about 10 hours in an appropriate ambient to obtain a coloured substrate.
2. A process as claimed in claim 1 wherein the substrate comprises a gemstone.
3. A process as claimed in claim 2 wherein the said gemstone is selected from the group consisting of topaz, chrysoberyl, sapphire, quartz and garnet.
4. A process as claimed in claims 1 to 3 wherein the substrate is cleaned before coating.
5. A process as claimed in claims 1 to 4 wherein the colour inducing/enhancing material is coated onto the substrate in the form of a thick or thin film depending on the intensity of the colour required for the final product.
6. A process as claimed in claims 1 to 4 wherein the colour inducing/enhancing material is diffused into the surface of the substrate.
7. A process as claimed in claims 1 to 4 wherein the colour inducing/enhancing material is chemically bonded onto the surface of the substrate.
8. A process as claimed in any preceding claim wherein said colour inducing/enhancing material comprises a metal or a metal oxide or a metallic compound/alloy.
9. A process as claimed in claim 8 wherein the said metal or metal oxide is a transition metal or a transition metal oxide respectively.
10. A process as claimed in claim 8 wherein said metal is selected from the group consisting of cobalt or a cobalt containing material, iron or iron containing material, chromium or chromium containing material, copper or iron containing material and any mixture thereof.
11. A process as claimed in claim 9 wherein said cobalt containing material is selected from the group consisting of cobalt-nickel-zircon, cobalt-nickel, cobalt silicide and cobalt oxide.
12. A process as claimed in claim 9 wherein said iron containing material is selected from the group consisting of iron-nickel-zircon, iron-nickel, iron-titanium and iron oxide.
13. A process as claimed in claim 9 wherein said chromium containing material is selected from the group consisting of chromium-nickel-zircon, chromium-nickel, chromium-aluminium and chromium oxide.

14. A process as claimed in claim 9 wherein said copper containing material is selected from the group consisting of copper-nickel-zircon, copper-nickel, copper-titanium and iron oxide.

15. A process as claimed in any preceding claim wherein said colour-inducing material comprises of two films of different metals.

16. A process as claimed in claim 15 wherein first metal film coated on gemstone is cobalt and the second film is of chromium.

17. A process as claimed in claim 16 wherein the substrate comprises coated topaz and is heated at a temperature range between 1000 to 1100°C in air or an inert or reducing gas for a time in the range of 30 minutes to 5 hours to induce Turquoise blue colour.

18. A process as claimed in claim 6 wherein the substrate comprises topaz and the said topaz substrate is heated at a temperature in the range of 1000°C to 1100°C in the presence of air or a reducing or an inert gas for a time in the range of 30 minutes to 5 hours to induce light blue to dark blue colour.

19. A process as claimed in claim 6 wherein the substrate comprises topaz and heating is done for a temperature range is 900°C to 1000°C in air or an oxidising gas for a time in the range of 30 minutes to 3 hours to obtain light green to dark green colour.

20. A process as claimed in claim 6 wherein to obtain green-blue or blue green topaz, the topaz substrate is heated in a temperature range of 950°C to 1050°C in air for such time till the colour is induced.

21. A process as claimed in claims 1 to 14 wherein said substrate comprises topaz and is heated at a temperature in the range of 700°C to 900°C in air or an oxidising gas for a time in the range of 30 minutes to 5 hours to induce yellow to reddish yellow colour.

22. A process as claimed in claims 1 to 14 wherein said substrate comprises topaz and is heated at a temperature in the range of 700°C 1050°C in air or an oxidising gas for a time in the range of 30 minutes to 5 hours to induce green colour.

23. A process as claimed in claims 1 to 14 wherein said substrate comprises topaz and is heated at a temperature in the range of 900°C 1100°C in air or a reducing gas for a time in the range of 30 minutes to 5 hours to induce pink to red colour.

24. A process as claimed in claims 1 to 14 wherein the substrate comprises Chrysoberyl and the colour obtained is yellow-green to blue-green depending upon the time and temperature of exposure.

25. A process as claimed in claims 1 to 14 wherein the substrate comprises colourless Chrysoberyl and the colour obtained is blue colour.

26. A process as claimed in claims 1 to 14 wherein the substrate comprises Sapphire and the colour obtained dark blue to light blue, or dark green to light green or a mixture thereof depending on the time and temperature cycle employed for the treatment.

27. A process as claimed in claims 1 to 14 wherein the substrate comprises Quartz and the colour obtained is light to dark pink.

28. A process as claimed in claims 1 to 14 wherein the substrate comprises Garnet and the colour obtained is green to blue-green when light yellow grossular garnet is used.

29. A process as claimed in any preceding claim wherein the colour inducing/enhancing film is coated onto the mineral substrate by physical vapour deposition and chemical vapour deposition.

30. A process as claimed in any preceding claim wherein said substrate is cleaned to remove dust, grease or any other foreign contaminant adhering to the stone surface.

31. A colour induced/enhanced mineral substrate prepared by the process of claims 1 to 30 wherein said substrate comprises a gemstone selected from the group comprising of topaz, chrysoberyl, sapphire, quartz and garnet.

32. A colour induced/enhanced substrate as claimed in claim 31 wherein the colour imparting/enhancing material is either diffused into the outer surface and/or chemically bonded to the surface atoms of thereof.

33. A colour induced/enhanced substrate as claimed in claim 31 or 32 wherein the colour inducing/enhancing material comprises cobalt or a cobalt containing material, chromium or a chromium containing material, iron or iron containing material, copper or copper containing material.

34. A colour induced substrate as claimed in claims 31 to 33 wherein said induced colour is blue or green or blue-green or green-blue, Swiss blue, green, yellow, reddish-yellow, pink, red, pinkish-red.

35. A colour induced substrate as claimed in claim 34, wherein said gemstone is topaz, and said induced colour is blue.

36. A colour induced substrate as claimed in claim 34 wherein the colour inducing/enhancing material is diffused into the substrate surface and/or chemically bonded onto the substrate surface.

37. A colour induced/enhanced substrate as claimed in claim 36 wherein the colour inducing/enhancing material is diffused into the substrate surface and/or chemically

bonded onto the substrate surface said colour inducing/enhancing material comprising cobalt or a cobalt containing material, chromium or a chromium containing material, iron or iron containing material, copper or copper containing material and wherein said gemstone is topaz, chrysoberyl, sapphire, quartz, or garnet.

38. A colour induced/enhanced substrate as claimed in claim 37, wherein said induced colour is blue, green, blue-green, green-blue or Swiss blue for cobalt and cobalt containing film materials, yellow or reddish-yellow for iron and iron containing materials, green for chromium and chromium containing materials, pink to reddish pink for copper and copper containing materials.

39. A process for imparting colour to a mineral substantially as described hereinbefore and with reference to the foregoing examples.

40. A colour induced/enhanced mineral substrate prepared by the process of claims 1 substantially as described hereinbefore and with reference to the foregoing examples.

Dated this the 9th day of July 2001.

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